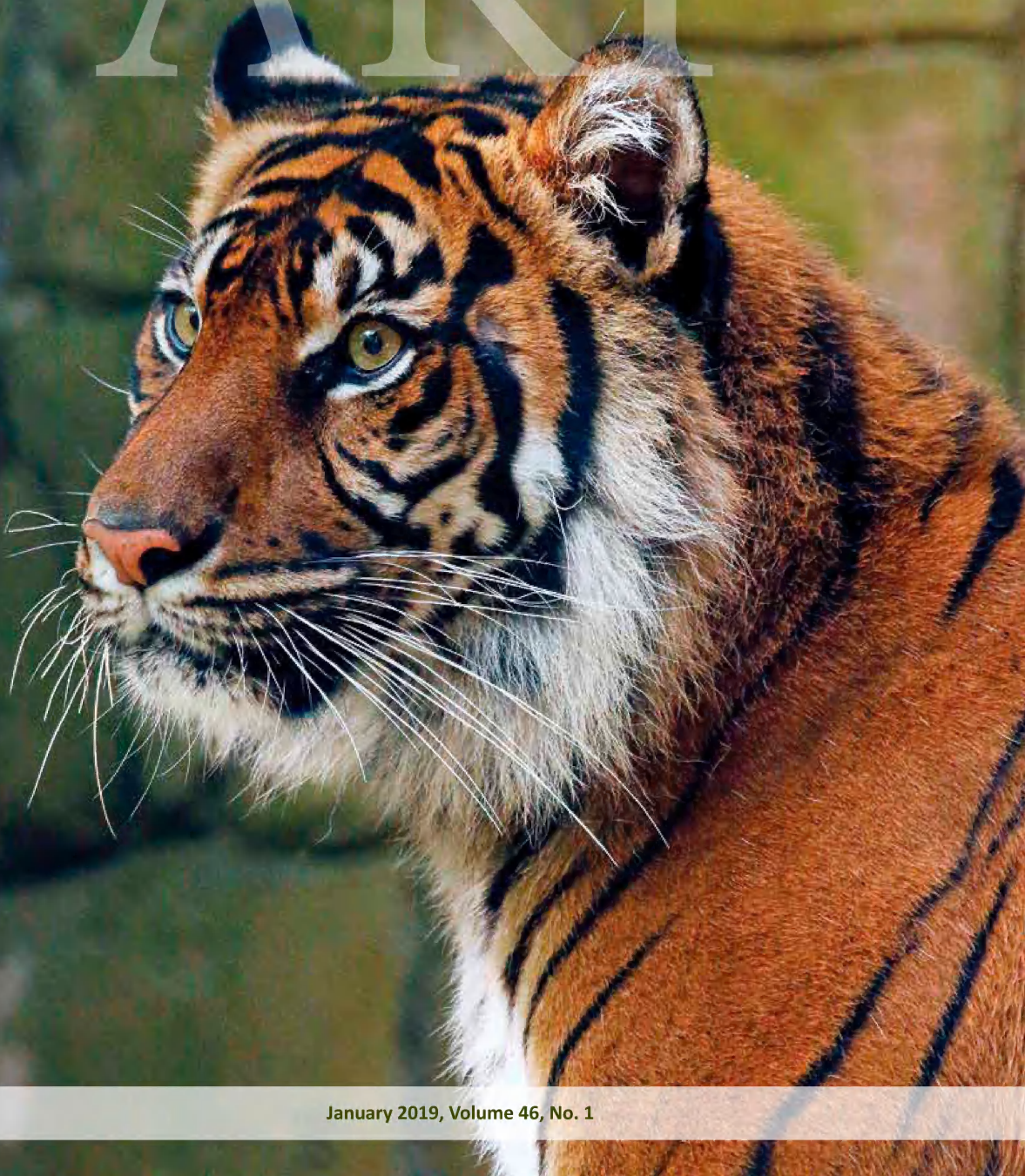



The Journal of the American Association of Zoo Keepers, Inc.

# Animal Keepers' Forum



January 2019, Volume 46, No. 1





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## MISSION STATEMENT

American Association of Zoo Keepers, Inc.

The American Association of Zoo Keepers, Inc. exists to advance excellence in the animal keeping profession, foster effective communication beneficial to animal care, support deserving conservation projects, and promote the preservation of our natural resources and animal life.

## ABOUT THE COVER

This month's cover features "Hadiah," a Sumatran tiger (*Panthera tigris sumatrae*) photographed by Dallas Zoo staff photographer Cathy Burkey. Hadiah is one of five tigers that call the Dallas Zoo home and recently celebrated her golden birthday this past December, turning 12-years-old. Hadiah is considered the zoo's sweetest tiger as she always greets her keepers with friendly cheek rubs, chuffs, and moos, although a boomer ball rolling towards her food is considered the most offensive. The Dallas Zoo has been the home to 2.3 Sumatran tigers for the past three years and through out-of-the-box management methods, they have been shown to be housed in a non-stressful environment despite being housed near individuals they do not prefer. Find out more on pages 10-16 of this issue.

Sumatran tigers are the smallest of six extant subspecies of tigers and are found only on the Indonesian island of Sumatra. Less than 400 Sumatran tigers exist today and due to these numbers, they are listed as critically endangered ([www.wwf.org](http://www.wwf.org)). Sumatran tigers are losing their habitat at an alarming rate due to forest clearing for agricultural needs and poaching has remained a significant contribution to decreasing tiger numbers.

Articles sent to *Animal Keepers' Forum* will be reviewed by the editorial staff for publication. Articles of a research or technical nature will be submitted to one or more of the zoo professionals who serve as referees for AKF. No commitment is made to the author, but an effort will be made to publish articles as soon as possible. Lengthy articles may be separated into monthly installments at the discretion of the Editor. The Editor reserves the right to edit material without consultation unless approval is requested in writing by the author. Materials submitted will not be returned unless accompanied by a stamped, self-addressed, appropriately-sized envelope. Telephone, fax or e-mail contributions of late-breaking news or last-minute insertions are accepted as space allows. Phone (330) 483-1104; FAX (330) 483-1444; e-mail is [shane.good@aazk.org](mailto:shane.good@aazk.org). If you have questions about submission guidelines, please contact the Editor. Submission guidelines are also found at: [aazk.org/akf-submission-guidelines/](http://aazk.org/akf-submission-guidelines/).

Deadline for each regular issue is the 3<sup>rd</sup> of the preceding month. Dedicated issues may have separate deadline dates and will be noted by the Editor.

Articles printed do not necessarily reflect the opinions of the AKF staff or the American Association of Zoo Keepers, Inc. Publication does not indicate endorsement by the Association.

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*As I look forward  
to the year ahead, I  
hope for each of you  
that it is filled with  
the opportunity for  
renewing your passions,  
embracing new  
challenges, celebrating  
new accomplishments  
and sharing with friends  
and co-workers.*

Happy New Year!

During the past year, the AAZK Trees for You and Me (TFYM) Program had the second most successful year in its history, raising a total of \$20,392.37. This was achieved through a combination of program T-shirt sales and individual Chapter fundraising efforts. This year, the program will celebrate its 10<sup>th</sup> anniversary and debut a special logo. I hope you will encourage your Chapter to participate in the third annual Treeblitz contest. The Chapter that raises the most funds for TFYM by April 1<sup>st</sup> will receive matching funds up to \$500 from Polar Bears International.

In 2018, two new members were appointed to the Board of Directors to fill the roles vacated by Azzara Ostons and Lee Hart; as they pursued new opportunities in their careers. Ellen Vossekui filled the role of Board Oversight for the Education Team, comprised of the Professional Development Committee and the International Outreach Committee. The newest member to join the Board is Nicole Pepo, who will be the Board Oversight for the Conservation Team, overseeing the Conservation Committee, the AAZK Trees for You and Me Program and the AAZK Bowling for Rhinos Program. In this issue of the AKF you will find a call for nominations for the AAZK Board of Directors. There are three (3) positions that will be open this year. I encourage you to nominate qualified Professional Members for the opportunity to fill these positions.

The Board of Directors also began the process of creating strategic plans for each of the committees and programs in 2018. This process is an in-depth focus on the strengths, weaknesses and objectives for each committee and program, and development of a three to five-year timeline for goal completion. The strategic plans will be complete for all 12 of the committees and programs during the Annual Meeting in Indianapolis this August.

Thank you – AAZK members, committee and program volunteers, Board leaders, social media followers, friends and family – for making the work we do possible. Thank you for your dedication and passion for animal care and conservation. As I look forward to the year ahead, I hope for each of you that it is filled with the opportunity for renewing your passions, embracing new challenges, celebrating new accomplishments and sharing with friends and co-workers. I'm grateful that I get to work with you and I look forward to continuing to lead the Association towards the future.

Sincerely,

Bethany Bingham  
AAZK President  
Bethany.bingham@aazk.org

## CALL FOR NOMINATIONS

### AAZK Board of Directors

The American Association of Zoo Keepers (AAZK) is seeking nominations for three (3) positions on the AAZK Board of Directors. Each candidate shall be nominated by a Professional peer within AAZK. Qualified candidates shall be active Professional Members in good standing with AAZK. AAZK Bylaws require that a Board Member have the title of Animal (Zoo) Keeper or similar, and if in a supervisory role at their facility, maintain daily husbandry contact with the animal collection. AAZK reserves the right to contact the candidate's employer to verify the candidate's job duties conform to AAZK policy. The electronic voting period to elect Board Members to the Association will be open from **May 1, 2019 to June 1, 2019** on the AAZK website.

#### Preferred Experience:

Experience as an officer in an AAZK Chapter, Committee Chair, or Conference Chair. Excellent organizational and time management skills, coupled with the ability to meet tight deadlines; problem solving and motivation of subordinates and quality public speaking skills.

#### Requirements:

Each elected candidate shall be required to attend monthly electronic meetings of the AAZK Board of Directors, read and answer daily electronic communications, supervise the work of Committees and/or Program Managers and shall be required to attend the annual AAZK Conference. An elected candidate can expect to commit anywhere from 4-6 hours per week in the performance of AAZK Board duties.

#### Nominations:

A Letter of Nomination shall include:

- Name of Candidate
- Zoo Affiliation
- Zoo Position Title
- Contact Information (address) including a phone number
- E-mail address

The Letter of Nomination shall include a brief synopsis of candidate work history, previous experience within AAZK and detail the number of years within the Profession. Deadline for Nominations to the AAZK Board of Directors shall be postmarked or e-mailed prior to midnight **February 28, 2019**.

Nominations can be sent to [Ed.Hansen@aazk.org](mailto:Ed.Hansen@aazk.org) or mailed to:

Ed Hansen, CEO/CFO  
AAZK, Inc.  
8476 E. Speedway Blvd., Suite 204  
Tucson, AZ 85710-1728

#### Reminder – AAZK Professional Members AAZK Board of Directors Electronic Voting

Candidate profiles for election to the AAZK Board of Directors may be viewed at [www.aazk.org](http://www.aazk.org) beginning **April 1, 2019**.

Professional Member electronic voting for candidates to the AAZK Board of Directors will open on the AAZK website ([www.aazk.org](http://www.aazk.org)) on **May 1, 2019** and will close at midnight **June 1, 2019**.



# COMING EVENTS

Post upcoming events here!  
e-mail [shane.good@aazk.org](mailto:shane.good@aazk.org)

**February 2-6, 2019**  
**11<sup>th</sup> Biennial Rhino Keeper Workshop**  
Orlando, FL  
Hosted by Disney's Animal Kingdom  
For more information go to:  
[rhinokeeperassociation.org/](http://rhinokeeperassociation.org/)

**February 4-8, 2019**  
**The SHAPE of Enrichment Workshop**  
Galveston, TX  
Hosted by Moody Gardens  
For more information go to:  
[registration@enrichment.org](mailto:registration@enrichment.org)

**February 5-7, 2019**  
**4<sup>th</sup> Annual Animal Training Workshop**  
San Antonio, TX  
Hosted by San Antonio Zoo  
For more information go to:  
[sazoo.org/trainingworkshop/](http://sazoo.org/trainingworkshop/)

**April 9-10, 2019**  
**Ape Cardio Workshop**  
Waco, TX  
Hosted by Cameron Park Zoo  
For more information go to:  
[greatapeheartproject.org/cpzworkshop/](http://greatapeheartproject.org/cpzworkshop/)

**April 13-18, 2019**  
**AZA Mid-Year Meeting**  
Phoenix, AZ  
Hosted by Phoenix Zoo  
For more information go to:  
[aza.org](http://aza.org)

**May 20-23, 2019**  
**International Giraffid Conference**  
Hosted by the Columbus Zoo and Aquarium.  
For more information go to: <https://reservations.columbuszoo.org/info.aspx?ActivityID=1875>

**May 22-24, 2019**  
**Chimpanzee SSP Husbandry Workshop**  
West Palm Beach, FL  
Hosted by Lion Country Safari  
For more information contact:  
[jennifer.ireland@nczoo.org](mailto:jennifer.ireland@nczoo.org)

**July 13-19, 2019**  
**Felid TAG:**  
**Husbandry Courses - July 13-15**  
**SSP Meetings - July 15-16**  
**TAG Meetings - July 17-19**  
Omaha, NE  
Hosted by Omaha's Henry Doorly Zoo and Aquarium  
More information coming soon!

**August 26-28, 2019**  
**Orangutan SSP Husbandry Workshop**  
Fort Wayne, IN  
Hosted by the Fort Wayne Children's Zoo  
For more information go to:  
<http://www.orangutanssp.org/2019-workshop.html>



**August 18-22, 2019**  
**AAZK National Conference**  
Indianapolis, IN

*Hosted by Indy AAZK and the Indianapolis Zoo*

[www.indyaazk.org](http://www.indyaazk.org)

**September 7-11, 2019**  
**AZA Annual Conference**  
New Orleans, LA  
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For more information go to:  
[aza.org](http://aza.org)



## 2019 AAZK AWARDS NOMINATIONS OPENED

The American Association of Zoo Keepers' Awards Committee is accepting nominations for The AAZK Lifetime Achievement Award, The AAZK Meritorious Service Award, The AAZK Lutz Ruhe Professional of the Year Award, The AAZK Jean M. Hromadka Excellence in Animal Care Award, The AAZK Excellence in Animal Nutrition Award, The AAZK Excellence in Exhibit Renovation Award, The AAZK Excellence in Zoo Keeper Education Award, The Nico van Strien Leadership in Conservation Award, and the Lee Houts Advancement in Enrichment Award which will be presented at the 2019 AAZK Conference in Indianapolis, IN.



The deadline for nominations is 1 May 2019. Information concerning the qualifications, nomination procedure, selection procedure and an explanation of the awards may be obtained at [www.aazk.org](http://www.aazk.org), under committees/awards.

## Attention All Photographers

The AKF needs your photos as potential cover photos and special feature photos throughout the issue. All photos need to be high resolution, 2625 x 3375 pixels or greater, and 300 dpi or greater in resolution. Photos that clearly depict facility logos and behind-the-scenes shots will need permission of the facility to be used.

Subjects for the photos should revolve around animal husbandry, conservation, education/interpretation, professional development, significant achievements in the industry (births, exhibits, staff, etc.), and can also include some of the more humorous or unique situations that we all come across each day in our occupations. Captions for each photo should also be submitted. Please submit photos to Editor Shane Good at [shane.good@aazk.org](mailto:shane.good@aazk.org).

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# Managing 2.3 Sumatran Tigers in a Rotating Group System to Mitigate Potential Social Stress and Promote Breeding at the Dallas Zoo

*Libby Hayes, Animal Keeper II, Dallas Zoo, Dallas, TX*

*Dr. Lara Metrione, Research Associate, South-East Zoo Alliance for Reproduction & Conservation, Yulee, FL*

*Photos by Cathy Burkey, Dallas Zoo, Dallas, TX*





## Abstract

The Dallas Zoo recently tackled the challenge of managing 2.3 Sumatran tigers in a way that better simulates more exclusive and more natural olfactory “territories” in an effort to minimize the potential stress from social housing and to improve opportunities for breeding. The tigers were divided into two separate housing groups, and a six-day management and cleaning rotation was established that provided each group with equal access to outdoor areas, minimized cleaning, and simplified tiger shifting and staff schedules. Fecal samples were collected before and after the management change and analyzed by enzyme immunoassay to measure fecal glucocorticoid and fecal estrogen metabolites (FGM and FEM, respectively) for assessing potential stress responses and estrus, respectively. Estrous behaviors also were recorded. Chronic elevations in FGM concentrations were not observed for any tiger. Two tigers had significantly lower FGM concentrations after the management change was implemented compared to before the change ( $p < 0.05$ ), whereas three tigers exhibited no change in FGM ( $p > 0.05$ ). The breeding pair had the lowest FGM of all the cats both before and after the management change. The target breeding female experienced elevated FEM potentially associated with estrus more often following the management change compared to before the change. Several estrous behaviors, including lordosis, were exhibited for the first time by the breeding pair after the management change was implemented. Based on FGM concentrations, it appeared that none of the tigers showed a chronic stress response under either management routine, but lower FGM in two tigers including the breeding female suggests that the new system might have provided some benefit to those individuals. More frequent estrus, as well as the observation of stronger estrous behavior, enabled introductions for breeding. With the aid of out-of-the-box thinking, the Dallas Zoo now manages five tigers in a way that is dramatically simpler for the keepers and that also benefits the tigers.

House Name	Gender	Birth Year
Hadijah	Female	2006
Kipling	Male	2006
Manis	Male	2004
Melati	Female	2006
Sukacita (aka ‘Suki’)	Female	2013

Table 1. Sumatran tigers housed at the Dallas Zoo in 2016/2017.

## Introduction

In the fall of 2016, the Dallas Zoo housed 2.3 Sumatran tigers (*Panthera tigris sumatrae*), and all five were recommended for breeding by the SSP. One pair had been together and bred for several years, but no pregnancies occurred. Another pair was behaviorally incompatible and could not be introduced. The third pair was a young female, and an older but inexperienced male, both of which were fairly new to the Zoo, having arrived in late 2015. This third pair was to be the focus of future breeding attempts. At that time, all of the tigers were rotated between one large habitat, eight bedrooms, and two outdoor holding yards with all cats utilizing all spaces. Behavioral concerns related to the tigers’ relationships with each other affected how the tigers could be physically shifted and housed every day. The males were antagonistic to the extent that they could not share doors/walls/viewing opportunities, etc., and there were other tiger combinations that had visual and door-sharing restrictions as well.

During the Carnivore Husbandry Certification Course at the 2016 American Association of Zoo Keepers (AAZK) Annual Conference, much discussion occurred about the amount of cleaning keepers do versus the need for animals to be able to smell their own scent. That discussion at the conference resonated with the challenges of housing multiple tigers at Dallas Zoo. Despite physical separation, the continuously-changing use of all spaces in the tiger building by all tigers facilitated constant olfactory communication between tigers with no sense of territory exclusivity.

Marking a territory with olfactory signals delineates resource access, invites mates, and warns competitors (Brahmachary and Poddar-Sarkar, 2015), and tigers communicate heavily via scent for those purposes (Gorman and Trowbridge, 1989; Brahmachary and Poddar-Sarkar, 2015). Staff were concerned that olfactory access to non-preferred tigers or potential competitors might be perceived as a stressor. In addition, staff were concerned that olfactory cues related to the other females’ estrous cycles would hinder the new breeding female’s cycle, or distract her mate. Indeed, he already showed more interest in a different female. None of the females showed overt signs of estrus on a predictable schedule. As a result, the Zoo decided to change the way the tigers were managed and simultaneously reduce cleaning in an effort to simulate more exclusive and more natural olfactory “territories”.

In this study, the Zoo investigated whether changing management strategies would lower stress levels and facilitate better opportunities for breeding. During a stress response, glucocorticoids (e.g., corticosterone and cortisol) are secreted from the adrenal cortex to increase the energy available for an animal to respond to the situation and restore homeostasis (Moberg, 2000). Over time however, if this otherwise-adaptive response becomes a chronic state of adrenal activation, the negative effects associated with stress can occur, such as a compromised immune system or reduced fertility (Moberg, 2000). In this study, whether high concentrations of fecal glucocorticoid metabolites (FGM)

## Dallas Zoo Tiger Building

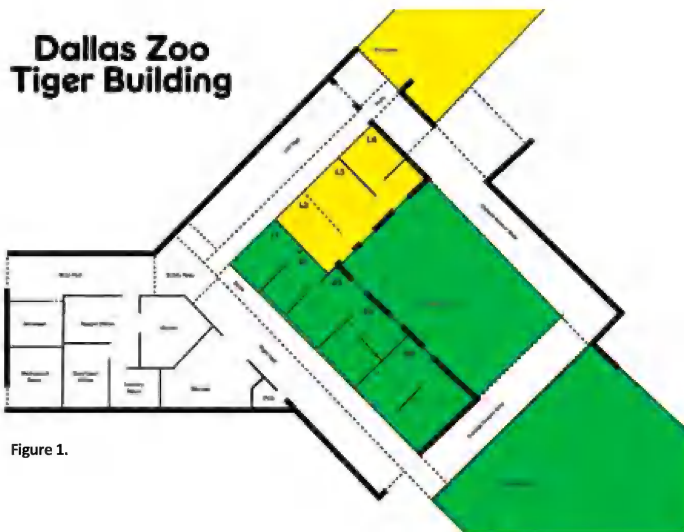


Figure 1.

## Dallas Zoo Tiger Building

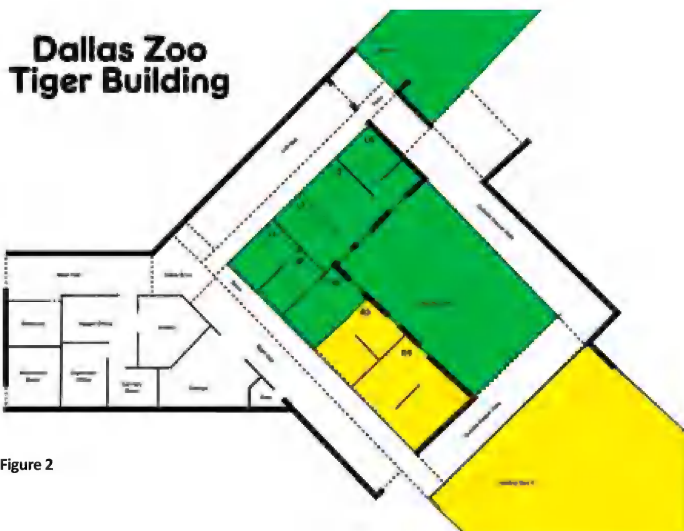


Figure 2

Figure 1. Map of tiger building where yellow represents the space that Suki and Manis utilize and green represents the space that Kipling, Melati, and Hadiyah utilize for a six-day period.

Figure 2. Inverse six-day rotation map of tiger building where yellow represents the space that Suki and Manis utilize and green represents the space that Kipling, Melati, and Hadiyah utilize for a six-day period.

were sustained over a long period of time, which might signal a chronic stress response, was examined, in addition to whether or not FGM were lower after the management change. Increases in fecal estrogen metabolite (FEM) concentrations are associated with estrus (Graham et al., 2006), therefore FEM were measured and estrous behavior was noted throughout the study to determine if opportunities for breeding improved after the management change.

## Methods

### Animals and Housing

All five Sumatran tigers (2,3) at the Dallas Zoo were involved in this investigation (Table 1). Tigers were fed Nebraska Brand® carnivore ground diet, bones, and rabbits. Tigers received routine veterinary examinations. Hadiyah was discovered in late 2017 to have an illness that required medical treatment, the symptoms of which were subclinical at the time of the study, but whether any early changes in her physiology might have occurred during the study is not known.

Building maps (Fig. 1-2) were created to indicate a new, specific layout in which tigers could be housed among the eight bedrooms (varies, each roughly 14 m<sup>2</sup>), single large habitat (~13,935 m<sup>2</sup>), and two holding yards (each ~84 m<sup>2</sup>). The new management approach separated the new breeding pair (Suki and Manis) from the other tigers so they only alternated spaces with each other. The three remaining tigers (Melati, Kipling, Hadiyah) alternated spaces with each other. Although Kipling and Melati were both equally agonistic toward Hadiyah, the ability for keeper staff to keep the breeding pair separate and still provide fair access to outside habitat and holding yard spaces required that those tigers be part of the same management group. To make sure that each tiger stayed in the habitat rotation and no animal became an off-habitat cat, a six-day management cycle was used: One group of tigers could access the hallway that connected to the habitat, and they would take turns on habitat over that six-day period. On the sixth day, tigers would



switch hallways so the other group of cats would be on habitat.

To facilitate scent separation and simultaneously minimize the amount of chemicals being used, a new cleaning schedule was adopted. The old cleaning routine involved rotating chemicals and scrubbing the entire building every day. The new routine used chemicals on the entire building only every third day, which included the day that the management groups had to switch hallways for habitat access as well as a day in the middle of the cycle. Following the disinfectant day, there were two days of 'light' cleaning that involved rinsing and minimal scrubbing of feed chutes and fecal spots only, a day of soap scrubbing the entire building, then two more days of 'light' cleaning. The habitat included natural substrates, bamboo, and other plants, and the holding yards consisted of gravel flooring and wooden benches and sand pits, therefore it was not possible to disinfect these areas.

### Fecal Sample Collection, Extraction, and Analysis

Fecal samples were collected approximately every other day for FGM and FEM analysis beginning approximately 2.5 months before management protocols were changed and then continuing for 3.5 months (for the males and Hadiah) or seven months (Suki and Melati) after the changes were implemented. To have the best possibility of representing the hormone concentrations secreted across the entire day, multiple segments from the entire scat were collected into a single bag, labeled with the individual tiger's identification and date of collection. In addition, collection days were aligned to include the day after the management groups switched hallway and habitat access to maximize the chance that a change in hormone concentrations, if present, might be detected in the fecal samples. Samples were stored frozen (-20°C) until analysis.

Each frozen fecal sample was crushed and homogenized, 0.5 g weighed, and hormone metabolites extracted in 90%

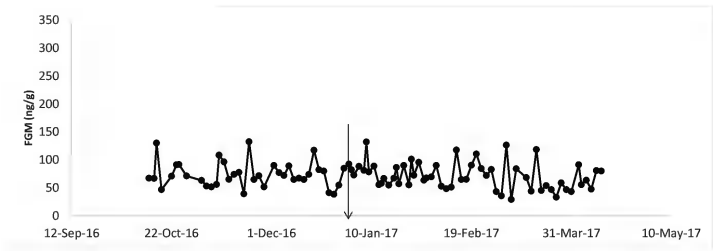


Figure 3. Fecal glucocorticoid metabolite profile for male tiger Kipling before and after a management change, indicated by the arrow.

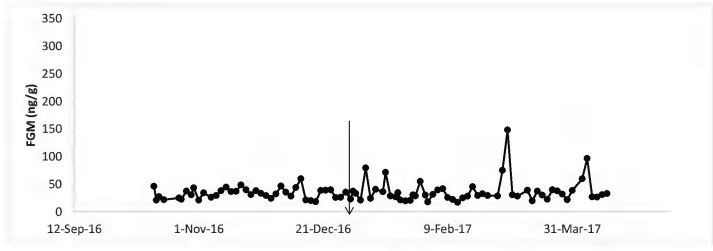


Figure 4. Fecal glucocorticoid metabolite profile for male tiger Manis before and after a management change, indicated by the arrow.

	Before		After	
	Frequency	Duration (days)	Frequency	Duration (days)
Suki	0 in 2.5 mo	--	3 in 7 mo	1.7 ± 0.3
Melati	0 in 2.5 mo	--	0 in 7 mo	--
Hadiah	1 in 2.5 mo	1	1 in 3.5 mo	2

Table 2. Frequency and average (± standard error) duration of elevated estrogen metabolite concentrations before and after a management change among three female tigers at Dallas Zoo.

ethanol by shaking for 15 min. Following centrifugation (10 min at 1347 ×g), the supernatant was decanted, diluted in assay buffer 1:10 for cortisol and 1:20 for estradiol, and assayed. The enzyme immunoassays (EIA) used antibodies for cortisol (cortisol-3-carboxymethyl oxime; R4866) and estradiol (1, 3, 5 (10)-estratrien-3, 17β-diol; R0008), both sourced from C. Munro, University of California, Davis, CA, USA. Antibody cross-reactivity was previously reported (cortisol, Narayan et al., 2013; estradiol, Barnes et al., 2015), and the cortisol antibody was previously validated for measuring tiger FGM (Narayan et al., 2013). To validate the estradiol assay, serial dilutions of pooled fecal extract generated dose-response curves parallel to serially-diluted hormone standard. Recovery of known amounts (0.078 to 10.0 ng/ml) of synthetic cortisol and

estradiol added to pools of diluted fecal extract was 90% (regression equation:  $0.783x + 4.58$ ,  $r^2 = 0.998$ ) and 101% (regression equation:  $0.904x - 0.326$ ,  $r^2 = 0.999$ ), respectively. Assay sensitivity was 0.078 ng/ml for both assays. Intra-assay coefficients of variation were <10% and inter-assay coefficients of variation were ≤10% for both assays. Hormone data are presented as ng per g of dried feces (ng/g).

Hormone metabolite concentrations were plotted over time for each tiger to generate a visual profile. Median FGM concentrations were calculated for the 2.5 months before and 3.5 months after the management change for each tiger and compared using a Wilcoxon rank-sum test. Baseline FEM concentrations were calculated using an iterative process in which values that exceeded

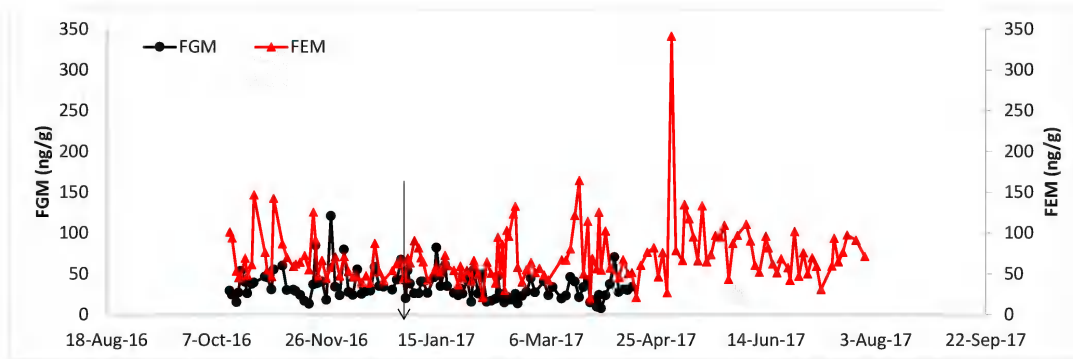


Figure 5. Fecal glucocorticoid and estrogen metabolite profiles for female tiger Suki before and after a management change, indicated by the arrow.

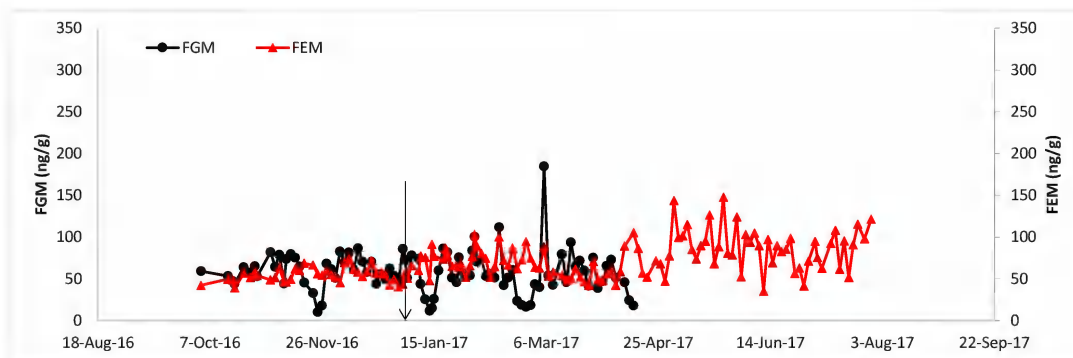


Figure 6. Fecal glucocorticoid and estrogen metabolite profiles for female tiger Melati before and after a management change, indicated by the arrow.

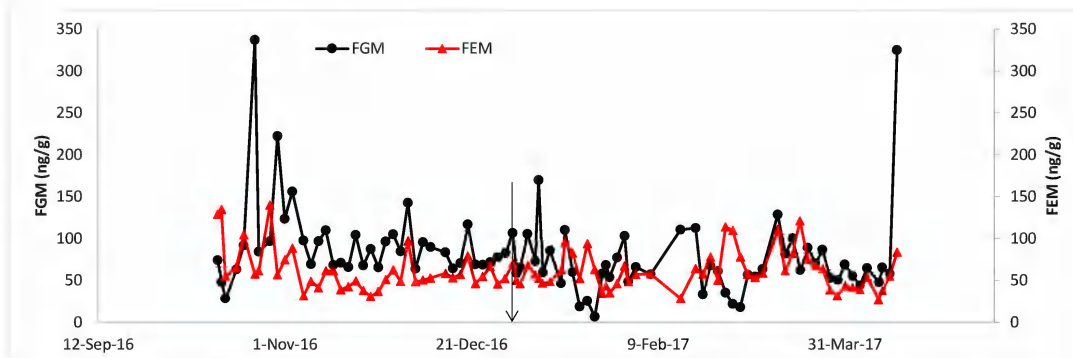


Figure 7. Fecal glucocorticoid and estrogen metabolite profiles for female tiger Hadiah before and after a management change, indicated by the arrow.



the mean +2 standard deviations (SD) were excluded, the mean recalculated, and the elimination process repeated until no values exceeded the mean +2SD (Graham et al., 2006). Baseline values were then calculated as an average of those remaining after all high values had been excluded. FEM were considered elevated and potentially indicative of estrus if  $\geq 2 \times$  baseline for  $\geq 2$  consecutive samples. The frequency and duration of elevated FEM potentially associated with estrus were compared before and after the management change.

### Behavioral, Physical, and Environmental Notations

In addition to their role in the stress response, glucocorticoids are essential to nutrient metabolism and regulating energy accessibility (Widmaier et al., 2008), therefore differences in the concentrations between individuals and over time can be due to diet, activity level, the season, where they are in their reproductive cycle, etc. To help separate these possibilities from a potential stress response in case dramatic and/or prolonged changes in FGM were observed, keepers made detailed entries in the daily records on any diet changes, illnesses, and reproductive behavior using Zoological Information Management Software (ZIMS) throughout the study. Detailed notes about estrous behavior included vocalizations, physical interactions, such as cheek and body rubbing at the shared mesh, laying near each other at the mesh, prolonged interest in each other, and the female exhibiting further behaviors, including rubbing on logs, rolling, and lordosis.

### Results

Chronic elevations in FGM concentrations were not observed for any tiger (Fig. 3-7). Rather, all tigers showed variable FGM concentrations throughout the study, with transient increases in FGM returning to baseline quickly. Three tigers did not show a change in FGM concentrations after the change in management was implemented ( $p > 0.05$ ), but two tigers did have significantly ( $p < 0.05$ ) lower

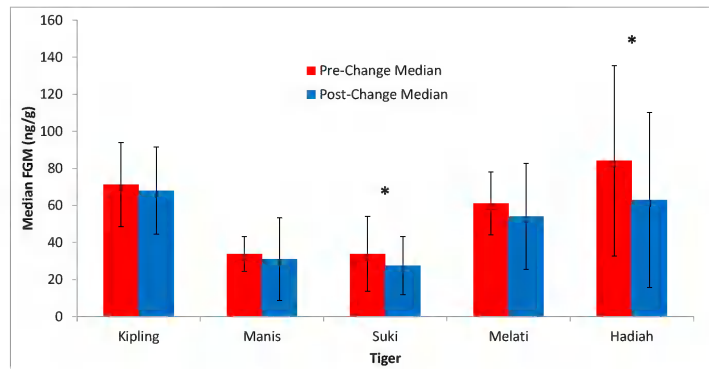


Figure 8. Median ( $\pm$ SD) fecal glucocorticoid metabolite (FGM) concentrations in five tigers at Dallas Zoo before and after changes to their management routine were implemented. Significant differences between pre- and post-change concentrations are indicated (\*).

FGM after the management change compared to before the change (Fig. 8). One of these tigers was Suki, the new breeding female. Suki and Manis, the breeding pair, had the lowest FGM of all the cats both before and after the management change.

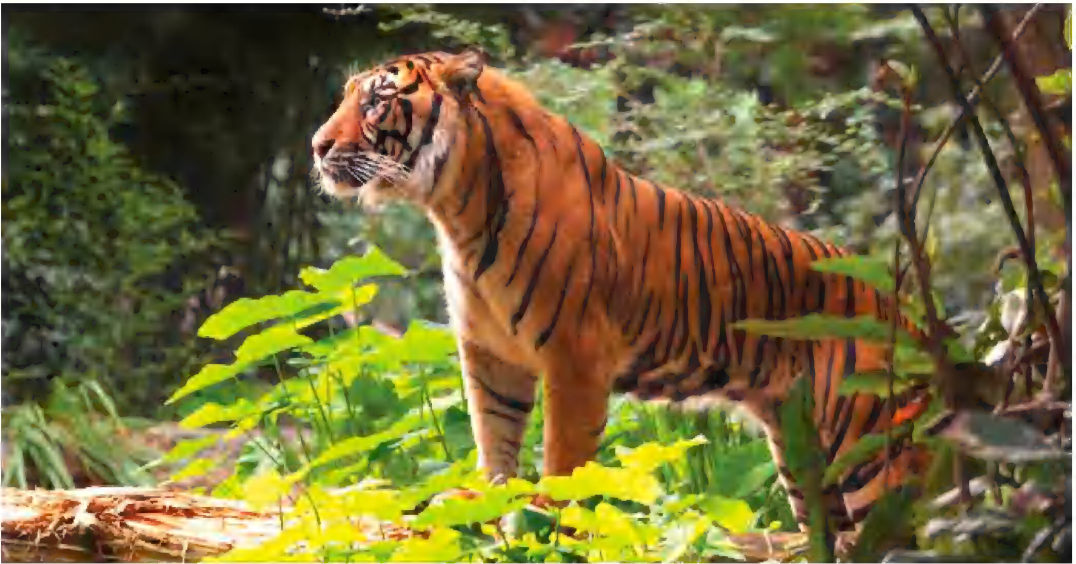
Suki, the focal breeding female, had elevated FEM potentially associated with estrus more often following the management change compared to before the change (Table 2). Before changing management plans, the types of behaviors observed between the breeding pair included chuffing, occasional cheek rubbing primarily by the female, and very rare and intermittent body rubs, rubbing on logs, and rolls by the female. All of those behaviors continued to be observed once the management change was implemented, and additional behaviors were noted, including pawing at the mesh by the male towards the female, interest on the part of both tigers lasting for more than ten continuous minutes, laying at their shared mesh wall, and the female displaying lordosis.

### Discussion

Based on the FGM profiles, it appeared that none of the tigers showed a chronic stress response under either management routine, and in fact, the breeding pair had the lowest FGM even before the management change was

implemented. The tigers appeared to respond to various stimuli they experienced, but FGM concentrations returned to baseline quickly. Decreased FGM in two tigers, including Suki, suggests that the new system might have been beneficial for those individuals, and there was no evidence of a detrimental effect of the new system on any tiger. Whether Hadiah's decrease in FGM might have been related to changes in her physiology that had not yet manifested as observable signs of illness is unknown. Suki's more frequent estrus and stronger estrous behaviors were additional positive outcomes of the management change. In fact, introductions for breeding were able to begin for the breeding pair in November 2017 and continue to date. However, because of Suki's young age, it is possible that maturation also may have contributed to these positive reproductive outcomes.

The six-day habitat rotation and cleaning schedule used in this study was chosen for multiple reasons. First, six days was not too long for one group of tigers to be without habitat access, which was the only place that certain behaviors (e.g., emergency recall) could be trained. Second, the intensive cleaning day of disinfecting the entire building as well as a long, complicated shift happened on different days of the



week every week, creating a balanced work-load across the keeper staff. Third, the new system improved efficiency and safety. Previous to the change, each day every tiger could go in any location, keepers were constantly worried about providing equivalent opportunities for all tigers to access outside spaces, and long complicated shifting was normal. While all tiger shifting is inherently dangerous, the Dallas Zoo management team prefers that there is no superfluous shifting. Using the new management system, both of those issues were dealt with simultaneously. Keepers no longer 'decide' which tigers will go in which places as there is a schedule into which equal outside access was already integrated. Relatively simple shifting accomplishes most of the tiger area changes during the week with only one longer, more complicated shift every six days. The Zoo continues this management schedule with the hope of maintaining positive wellbeing for the tigers and promoting reproductive success for the breeding pair.

## Acknowledgements

We would like to thank all the carnivore staff at the Dallas Zoo that collected fecal samples and supported this project. We also thank Kim Daly-Crews for performing the assays and Dante Dartiguenave for assisting with fecal processing and data analysis.

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# Assessing and Managing Changing Troop Dynamics of a Bachelor Troop of Francois Langurs (*Trachypithecus francoisi*)

Amy Sarno, Australasia Team Lead, Kansas City Zoo, Kansas City, Missouri

## Author's note:

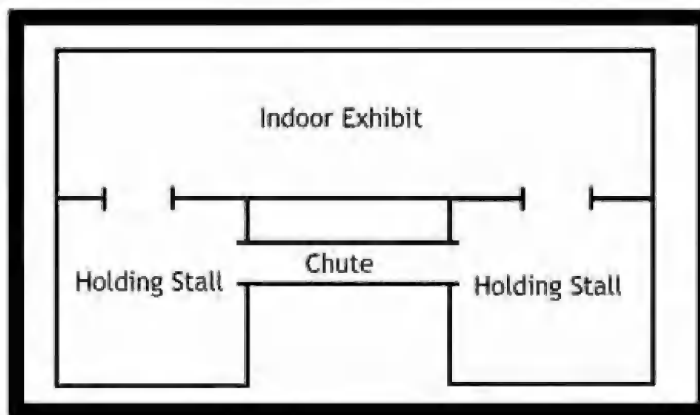
Originally presented at the 2017 Old World Monkey TAG Husbandry Workshop. Paper includes updated information based on events occurring after initial presentation and then presented at the 2018 AAZK Conference.

Kansas City Zoo houses a troop of 4.0 Francois langurs (*Trachypithecus francoisi*) that have been together since 20 July 2012. To establish this bachelor group, two sets of two unrelated individuals were introduced to each other. The subsequently formed pairs were then introduced to each other. The initial pairings formed bonds that remain strong to this day. Once

the troop was established, a clear dominance hierarchy was evident; however, over the last few years there has been an observable shift in the dominance order. A year's worth of behavioral data were collected to assess the troop's dynamics and quantify these observed changes. Following the assessment, a cooperative shifting plan was created and implemented. The

goals of the training are to eliminate any displacement of subordinate individuals and allow zookeepers to easily shift all four individuals into indoor holding to facilitate servicing of the exhibit. Additionally, improvements were made to the crate training strategy used to move the langurs between buildings, which occurs twice each year.

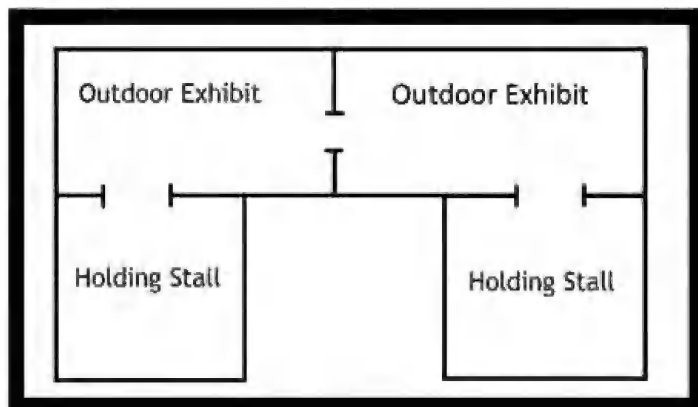
Chay (left) and Fu (right) in indoor exhibit.  
Photo by Fulani G. Jabri





## Background

The current troop is composed of “Chay”, born September 3 2008 at Toledo Zoological Gardens, “Fusui” (Fu), born 5 September 2007 at Lincoln Park Zoological Gardens, “Han” born 4 December 2007 at Oregon Zoo and “Sean” born 31 August 2006 at San Antonio Zoological Gardens & Aquarium. After clearing quarantine, Chay and Fu were introduced in an off exhibit building on 7 December 2011 and Han and Sean were introduced in a different off-exhibit building on 21 February 2012. Once the pairs were successfully introduced all four langurs were put together in their new building on 20 June 2012. As is common with Old World Monkey introductions, some aggression occurred during the introductions of the pairs, as well as with the full troop introduction, but nothing overly concerning or unexpected occurred. Periodic chasing and displacing is still observed by zookeepers. The pair bonds of Chay with Fu and Han with Sean have been strong from the beginning and remain well-established today. The initial dominance hierarchy within the pairs was Chay over Fu and Sean over Han, with Han and Sean ranking higher than Chay and Fu. The troop is exhibited in an indoor, climate controlled, building in the winter and an outdoor exhibit in the summer, which requires moving them twice a year. The zoo’s red panda pair occupy their exhibits in the opposite seasons. The buildings have different set-ups and sizes that require different management practices. The indoor building is smaller but has an overhead chute connecting the two holding stalls (Figure 1), while the outdoor building has a larger area, dividable exhibit but no overhead chute between the stalls (Figure 2). When the troop is in the indoor exhibit, they are always given access to the exhibit and all of the holdings to provide them adequate space. The larger outside area allows them to be locked on exhibit during hours of operation without issue. Historically, the pairs have shifted into their respective holding stalls to be locked in together without issue to allow zookeepers to service the exhibit.



Following the troop’s establishment, interactions between the langurs remained relatively calm through the end of 2013, at which point the instances of fights and subsequent wounds gradually increased, peaking in the first half of 2016 (Figures 3a and 3b). Beginning in 2015, zookeepers began noticing an increase in turmoil in the troop; frequently observing Chay going after Han and Sean with the occasional help of Fu. To better quantify and understand these changing dynamics a behavior study was embarked upon.

## Data Collection

Beginning in December of 2015,

behavioral observations were collected using an ethogram created specifically to monitor the changing troop dynamics and to document interactions between individuals (Figure 4). Specifically, the ethogram aimed to quantify positive and negative interactions, any displacement from food or enrichment, any patterns associated with aggression and overall time budget relative to conspecifics. A total of 120 ten-minute observations were collected between 13 December 2015 and 31 December 2016. Fifty-five of the observations were conducted in the outdoor exhibit from 17 April 2015 through 30 October 2015 and 64 observations took place in the indoor exhibit from 13 December 2015 through

Figure 3a – Wounds Sustained Since Formation of Troop

Dates	Number of Wounds Sustained	Number of Wounds Requiring Treatment*
2012	3**	2
2013	0	0
2014	10	1
2015	27	16
Jan-Jun 2016	16	6
July-Dec 2016	2	0
2017	3	0
Jan-Sept 2018	6	2

\*Treatment included oral pain medications, anti-inflammatories, antibiotics and/or a topical flush.

\*\*All wounds in 2012 were from initial introductions

Figure 3b – Number of Wounds Received Per Individual

Year	Chay	Fu	Sean	Han
2012	0	0	2*	1*
2013	0	0	0	0
2014	4	3	0	3
2015	2	5	11	9
2016	2	3	8	5
2017	0	3	0	0
2018	1	4	1	0

\*All wounds in 2012 were from initial introductions

3 April 2015 and 6 November 2015 through 21 December 2015. All of these observations were conducted by the author to ensure data consistency and due to the langurs being difficult to quickly tell apart, except by their primary zookeepers.

## Results

Analysis of the data showed several interesting patterns (see Figures 5 and 6 for complete data). Han and Sean spent more time in spacial proximity of each other (defined as close enough to touch) than Chay and Fu did.

Additionally, Han and Sean engaged in more positive interactions with each other (defined as grooming each other and being in spatial proximity without any agnostic behavior) as compared to Chay and Fu (Figure 7). Negative interactions (defined as any form of displacing, chasing, fear grimacing or attacking) between the partners were not surprisingly low, however the percentage of negative interactions between Chay and Fu, while still very small, were nearly eight times more common than those observed between Han and Sean. Positive interactions between any langur and one of their

non-partners were very low, as expected. One of the surprising trends observed was that the dominant langur in each pair spent approximately twice as much time grooming their partner, compared to the time they were groomed by the partner.

Spacial usage of the exhibit was also analyzed (Figure 8), which showed all pairs being in the same section of the exhibit less than half the time, the pairs being together in opposite sections of the exhibit approximately one-third of the time, one individual in one section and the remaining three in the other less than one-fourth of the time and two non-paired individuals in each section two percent of the time. Of the observations of an individual being in a section alone and other three in the other section together, it was Chay alone 37% of the time, Fu alone 27.3% of the time, Han alone 20.3% of the time and Sean alone 15.4% of the time. Both pairs spent the majority of the time in the same section with each other, but Han and Sean were in the same section more frequently than Chay and Fu.

When looking at the interactions of the langurs with individuals that were not their partner, the results show that the langurs spent a very small percentage of their time interacting in any manner with a langur that was not their partner (Figure 7). Of the documented interactions with non-partners, negative encounters were approximately five times more frequent than neutral or positive interactions. The negative interactions were comprised of Fu initiating the most aggression out of the four, and Sean being aggressed upon the most frequently. Full body checks are conducted by zookeepers during training sessions to look for wounds and assess overall health of each langur on a weekly basis, or as needed, following an observed fight or evidence of an altercation. All wounds are recorded in daily records and monitored closely by zookeepers. Langurs, like most Old World Monkeys, are resilient healers so often times injuries did not require veterinary intervention. For the cases

Kansas City Zoo's bachelor troop in the indoor exhibit. From left to right; Chay, Fu, Han, Sean.  
Photo by Amy Sarno





Figure 4 – Ethogram

Category	Behavior	Code	Description of Behavior
Social	Grooming a conspecific	GC	Uses hands and/or mouth to pick through fur and/or mouth of conspecific, excluding anogenital region
	Being groomed by a conspecific	BG	A conspecific is picking through their hair with hands and/or mouth
	Chasing a conspecific	C	Actively pursuing conspecific
	Being chased by a conspecific	BC	Moving away from conspecific who is actively pursuing them
	Displacing a conspecific	DC	Moving toward a conspecific who then moves away as a result
	Being displaced by a conspecific	BD	Moving away from a space when a conspecific approaches
	Attacking a conspecific	A	Aggressing on a conspecific; involving physical contact
	Being attacked by a conspecific	BA	Being aggressed on by a conspecific; involving physical contact
	Inspect anogenital region of conspecific	I	Uses hands or mouth to investigate and/or groom anogenital region of conspecific
	Having anogenital region inspected by conspecific	IC	A conspecific uses hands or mouth to investigate or groom anogenital region
	Sitting next to conspecific	SC	Resting in spacial proximity to conspecific
	Baring teeth to conspecific	BT	Making any threatening facial gestures to conspecific
	Vocalizing	V	Grunting, barking, screaming, etc.
Enrichment	Interact with enrichment	IE	Smells, touches or manipulates an enrichment item
	Displace conspecific from enrichment	DE	Chases conspecific away from a desired enrichment item
	Displaced from enrichment by conspecific	ED	Drops/leaves an enrichment item currently using when approached by conspecific
Solitary	Grooming self	GS	Uses hands and/or mouth to pick through own fur
	Resting	R	Staying stationary but is awake and alert to environmental changes
	Sleeping	S	Staying stationary but eyes are closed and is not alert to environmental changes
	Locomoting	L	Walking, climbing, swinging or running from one place to another
	Interact with environment	IV	Peeling bark of perching, picking up mulch, etc.
Food	Eating diet	E	Eating a piece of food from diet
	Eating enrichment item	EE	Eating an enrichment item
	Drinking	D	Drinking water

Figure 5 -Time Budget of Langurs During Observations

BEHAVIOR CATEGORY	BEHAVIOR	CHAY	FU	HAN	SEAN
Positive Interaction With Partner	Grooming Partner	4.2%	2.0%	1.6%	4.0%
	Being Groomed By Partner	2.1%	4.1%	3.9%	1.6%
	Spatial Proximity of Partner	26.1%	25.2%	34.3%	35.2%
Negative Interaction with Non-Partner(s)	Negative Interaction Toward Non-partner(s)	2.1%	3.3%	0.1%	1.4%
	Aggressed on by Non-partner(s)	1.4%	1.2%	2.6%	3.2%
	In Spatial Proximity with Non-Partner(s) with Agnostic Behavior	0.2%	0.0%	0.3%	0.2%
Positive Interaction With Non-Partner(s)	Grooming Non-Partner(s)	0.0%	0.0%	0.1%	0.0%
	Being Groomed by Non-Partner(s)	0.0%	0.1%	0.0%	0.0%
	In Spatial Proximity with Non-Partner(s) no Agnostic Behaviors	0.7%	0.3%	0.4%	3.7%
Negative Interaction with Partner	Negative Interaction from Partner	0.1%	0.5%	0.1%	0.0%
	Negative Interaction Toward Partner	0.3%	0.1%	0.0%	0.1%
All Other Non-Interactive Behaviors	Other	62.8%	63.2%	56.6%	50.6%

Author's Note: Each langur has a different number of total observed behaviors due to them being non-visible at various observation points

when wounds were more severe, they were treated with any combination of main medications, anti-inflammatories, antibiotics and topical flushes.

Additional notable observations were made during the study period related to diet, grooming and responses to aggression. In every instance when the troop was given access to food and/or

browse, Chay and Fu would immediately go and start eating, while Han and Sean would wait before running to quickly grab items and then carry them away. There were several observations of Fu stealing desirable food items from both Han and Sean, but never from Chay. Chay would also periodically displace Fu in order to take browse or desirable food items. Han and Sean were never observed taking or attempting to take food items. Han primarily groomed Sean, but there were a few instances when he was observed grooming Chay and Fu. No other langurs were observed grooming any individual that wasn't their partner. Han was never groomed by Chay or Fu. While Han never initiated any fights, there were occasional instances when he would attempt, unsuccessfully, to displace Chay; in response to these attempts Chay would hold his ground and Han would retreat.

Sean relaxing in indoor exhibit.  
Photo by Jeromy Bell



## Analysis of Data

The data support the casual observations zookeepers had made prior to the study, that the langurs spend most of their time with their partner and little time with the other two langurs. Several data points show an interesting result that wasn't necessarily obvious by casual observation; that Han and Sean's bond appears to be a stronger and less volatile bond, as compared to the bond between Chay and Fu. The fact that Sean received the highest amount of aggression directed toward him supports the conclusion that Chay and Fu were overtaking his previously held alpha status. The data show a shift from Han and Sean, who previously were the pair to get desirable food items first, to Chay and Fu holding that position of dominance. Han's drop in social status, from second most dominant to most subordinate individual, is represented by him grooming Chay and Fu and not being groomed by them in return.

The breakdown of which individuals received wounds over the years reflects the shift in dominance hierarchy (Figure 3b). Aside from the wounds Sean incurred during the initial introductions to Han, he didn't receive any wounds while he was the alpha from 2012-2014. Once the dominance began to shift to Chay in 2015 and 2016, Sean received a total of 19 wounds. Once Chay was firmly established as the new alpha and the number of fights decreased, Sean has only received one wound since 2017. Similarly, Han didn't receive any wounds, aside from the one received during initial introductions to Sean in 2013 and only three in 2014, but in 2015 and 2016 when he lost his beta status and became the most subordinate individual, he sustained a total of 14 wounds. Han has only received two wounds since 2017 after the troop dynamics stabilized. The number of wounds that Chay received annually was less after becoming alpha but is surprisingly low in 2015 and 2016, considering the number of altercations he was in while working to overthrow



Sean. This can likely be explained by him being the one inflicting wounds and rarely being injured. Fu received the highest number of wounds in 2015 at the peak of Fu and Chay's overthrow of Han and Sean but continued to have a few each year and the most in 2018 so far, as a result of Chay's reduced tolerance of him.

### Challenges of Changing Troop Dynamic

With Chay as the new alpha, Fu became increasingly reluctant to shift off exhibit and be locked into a stall with him. Zookeepers would often observe Chay chasing and displacing Fu before the pair could be locked inside together, and aggressing upon him on the occasions where zookeepers were able to shift them in as a pair. The previous management practice of locking both pairs into their own stall to service the exhibit was no longer possible with this changing dynamic between Chay and Fu. In the indoor building, zookeepers were able to utilize the overhead chute to get Fu locked in the chute after Chay was secured in a stall; thus leaving an empty stall to shift Han and Sean into. However, in the outdoor building, where there is no chute in holding, this was not an option and an alternative plan was needed.

The plan to address this new shifting issue was to train the troop for cooperative shifting and stationing. The ultimate goal of the training was to make shifting both pairs in together a much quicker and stress-free process, for both zookeepers and langurs, by having each langur go to their individual station to receive reinforcement without any individual being displaced.

### Training Plan

**Cue:** Visual hanging shape that is different for each langur and a verbal "station"

**Bridge:** whistle

**Criteria:** Dominant individual shifts into stall and sits on his station, stays there calmly and allows subordinate animal to go to his station and be reinforced. Both stay on station and allow door to

Figure 6 - Breakdown of All Interactive Behaviors

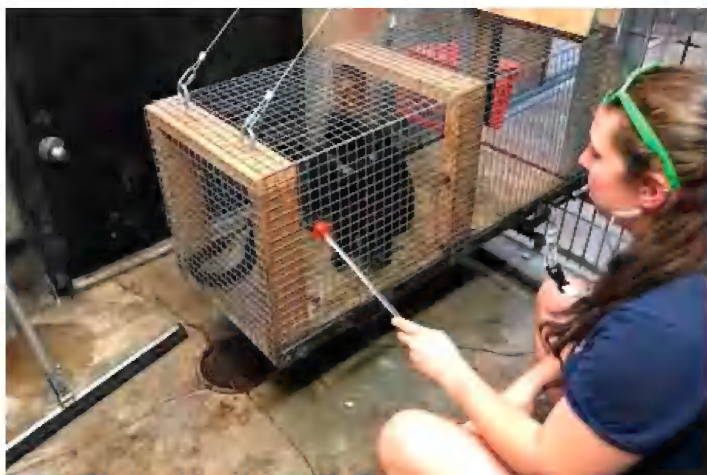
BEHAVIOR CATEGORY	BEHAVIOR	CHAY	FU	HAN	SEAN
Positive Interaction With Partner	Grooming Partner	11.2%	5.5%	3.6%	8.6%
	Being Groomed By Partner	5.5%	11.2%	8.7%	3.5%
	Spatial Proximity of Partner	69.1%	68.2%	76.9%	75.9%
Negative Interaction with Non-Partner(s)	Negative Interaction Toward Non-partner(s)	5.6%	8.9%	2.1%	3.0%
	Aggressed on by Non-partner(s)	3.7%	3.1%	5.9%	6.9%
	In Spatial Proximity with Non-Partner(s) with Agnostic Behavior	0.5%	0.0%	0.6%	0.4%
Positive Interaction With Non-Partner(s)	Grooming Non-Partner(s)	0.0%	0.0%	0.3%	0.0%
	Being Groomed by Non-Partner(s)	0.0%	0.1%	0.0%	0.0%
	In Spatial Proximity with Non-Partner(s) no Agnostic Behaviors	1.8%	0.8%	0.9%	0.8%
Negative Interaction with Partner	Negative Interaction from Partner	0.4%	1.3%	0.2%	0.0%
	Negative Interaction Toward Partner	0.9%	0.4%	0.0%	0.2%

Author's Note: Each langur has a different number of total observed behaviors due to them being non-visible at various observation points

be closed behind them and until they are released from station.

### Steps for Phase One:

1. Bridge and reinforce dominant animal every time he sits on his crate in front of his hanging station.
2. Add verbal "station" cue and point to station to draw his attention to the hanging station and reinforce for sitting calmly on crate.
3. Continue pairing station cue to the crate/hanging station until the cue is established. Can target him away from the station and give cue and bridge/reinforce when he goes to station.
4. Give dominant animal station cue, bridge and reward as soon as/every time he looks over at subordinate animal in doorway and/or if subordinate comes all the way into holding. Dominant animal must remain calmly on his station without displacing subordinate animal.
5. Continue step 4 until he is consistently looking over at subordinate animal and the connection is established between reinforcement and the presence of the subordinate animal.
6. Give dominant animal station cue, bridge and reward for staying calmly on station and looking back at trainer once subordinate animal enters holding.
7. Repeat step 6 until the behavior is consistent.
8. Give station cue to dominant animal and bridge/reinforce (with high value peanuts) for staying calmly on station while a lower value reinforcement item (produce) is delivered to subordinate animal for coming into holding
9. Continue step 8 as long as needed until criteria is consistently met.



A crate training session with the author and Fu. Photo by Sara Markway.

Figure 7 – Social Interactions as a Percentage of Total Observations

Langur	Positives with Partner	Negative with non-partner(s)	Positive with non-partner	Negative with Partner	No Interaction
Chay	32.4%	3.7%	0.7%	0.5%	62.7%
Fu	31.4%	4.4%	0.4%	0.5%	63.3%
Han	39.8%	3.9%	0.5%	0.1%	55.7%
Sean	40.7%	4.8%	0.4%	0.1%	54.0%

Figure 8 – Spatial Usage of Exhibits

Location	Percentage
All Four in Same Section	42.7%
One Pair in Each Section	33.2%
Three in One Section, Single in Other	22.1%
In section alone with Non-Partner	2.0%

10. Bridge/reinforce dominant animal staying calmly on station and focused on keeper while subordinate animal enters holding, receives produce and door is closed. At first will open door right away and build up to it being closed for longer periods of time.
11. Repeat step 10 until behavior is consistent and door is able to be closed for long enough to service exhibit.

Phase one is complete when the dominant animal will come to station when cued and remain there calmly, focused on the keeper while subordinate

animal enters holding and received reinforcement; both allow door to be closed. Once door is closed and both monkeys have received their reinforcement they are both free to go/ do whatever.

#### Steps for Phase Two:

1. Cue dominant animal to station and reinforce for allowing subordinate animal to receive reinforcement on platform near door. Door will not be closed at this step.
2. Once subordinate animal is consistently sitting on platform and dominant animal allows him to be reinforced without leaving station,

begin closing door again.

3. Once both animals consistently stay on stations for door closing, move the subordinate animal's station to the crate on the mesh; subordinate animal's station is lower on mesh than dominant's to start with. Introduce subordinate animal's hanging station and introduce the verbal station cue. Dominant receives peanuts, subordinate produce.
4. Once both animals are consistently going to their respective stations on cue and dominant animal allows subordinate to be reinforced, move the dominant animal's crate lower and the subordinate's higher until they are level with each other. May need to do an intermediate step if this proves to be too big of a jump.
5. Once both are consistently stationing at level crates, move the subordinate animal's crate higher above the dominant's; may need to make gradual approximations to reach final locations based on their response.
6. Once both animals are consistently stationing at their final station heights, begin using peanuts as reinforcement for both. Behavior is complete when both animals go to their respective stations on cue, allow the door to be closed behind them and allow each other to be reinforced. Once door is closed, hanging stations are removed and monkeys are free to move about the stall.

Cooperative shifting and stationing were able to be trained for Han and Sean and are currently being used to shift them daily. Chay and Fu proved to be a much larger challenge with Chay frequently displacing Fu before much progress could be made on the behavior. The new area primary is currently working on training this behavior but in the meantime a modified shifting plan was created. Chay is the first to



Final station behavior with Sean (left) and Han (right) in outdoor exhibit holding. Photo by Amy Sarno.

be called into an empty stall and then Fu is called into the other empty stall. Because of their lower rank, Han and Sean do not attempt to come inside when the opportunity for reinforcement exists while still with Chay and Fu, so locking the dominant two inside is not a problem. The next step is to utilize the dividable exhibit and get Han and Sean secured onto one half of the exhibit to clean and set up the empty half. Fu is then shifted out with Han and Sean. Because Fu is dominant over Han and Sean, when the door is opened to the set-up half of the exhibit, he shifts readily and the other two don't attempt to follow him. Chay can then be shifted out with Fu. Due to their dominance order, Fu is unlikely to shift over to food if Chay is already there. Lastly, Han and Sean can then be called into their stations to service the other half of the exhibit.

With the new dominance order established in the troop, modifications to the voluntary crate training plan were made that allowed all four to be voluntarily crated for the first time ever. In previous years only one or two langurs would voluntarily crate and the remaining individuals needed to be pushed into crates using aversive stimuli. With the modified plan, during training sessions, as well as for actual moving day, langurs were called into

holding and crated in order of their dominance ranking. All training sessions, practice and actual crating, were conducted with windows blocked and no other langurs in holding, so they could not see troop mates being crated. Additionally, after a langur was crated, zookeepers carried them to the new building the longer way around so that the other langurs could not see that they had been crated and were being moved. In previous years the individuals seeing each other being locked in the crates and moved may have negatively affected the subsequent crate training sessions.

## Discussion

Bachelor troops are an important management tool for this endangered species to create placement for non-breeding males within the population. With a bachelor troop of unrelated Francois Langurs being a relatively new management practice, there was not much previous history to go on, so it was necessary to be vigilant to dominance order and any changing dynamics that occurred so that husbandry practices could be adjusted to best accommodate working with the troop. The decision to create bonded pairs before introducing the whole troop together proved to be an excellent management strategy as it has allowed for each langur to have

a resource for confidence and normal social behaviors as well as aiding in shifting the troop. The Kansas City troop was intentionally formed of individuals close in age, but there is discussion amongst the SSP and TAG leadership about trying to form a troop with one older male and 2-3 younger males to create a father-like figure to possibly help manage aggression between male troop members. Regardless of the makeup of the troop, close observation of interactions between individuals, as well as a comprehensive training program are helpful tools for managing a bachelor group.

Since the conclusion of this study, zookeepers have begun noticing Chay and Sean spending increasing amounts of time with each other and engaging in mutual grooming, beginning in January of 2018 and continuing through the present. To date, this new development has not resulted in any needed adjustments to husbandry or management practices but indicates another possible shift in the hierarchy in the future. Continued diligent observations of troop behavior will be necessary to maintain best management practice for this group.

## Acknowledgments

This behavioral study and the subsequent training of the troop would not have been possible without the support of my management staff and teammates on team Australasia. I would especially like to thank Stacia Peroni for her guidance in creating the cooperative shifting and station training plan and for her support of my study. Additional special thanks are due to Sara Markway for her dedication of taking over their training once becoming the area primary. I would additionally like to thank the Kansas City Zoo maintenance staff for crafting our custom langur crate that greatly improved our training program. 🐒



# The Whole Truth About Variable Reinforcement Schedules

*Christina Alligood, Michelle Skurski, and Angela Miller  
Disney's Animal Kingdom®  
Lake Buena Vista, Florida*

Over the past few years, we have developed and conducted a series of workshops for animal care staff on topics at the intersection of the science of behavior and the practice of behavioral husbandry. Our hope is that, over time, the connection between these areas will become seamless.

The first workshop we developed was on variable schedules of reinforcement. We became interested in this topic as it relates to animal training after seeing

Ken Ramirez's presentation at the International Marine Animal Trainer's Association Annual Conference in 2014. Ramirez's careful explanation inspired us to broach this topic with our animal care staff in the hopes of disentangling some concepts that seem, often, to get jumbled together. The resulting workshop became the first in a series in which we discuss the science behind a training concept, its typical use in animal training, and how we might improve our practices. In this case, the take-home

points that we shared with our animal care staff were:

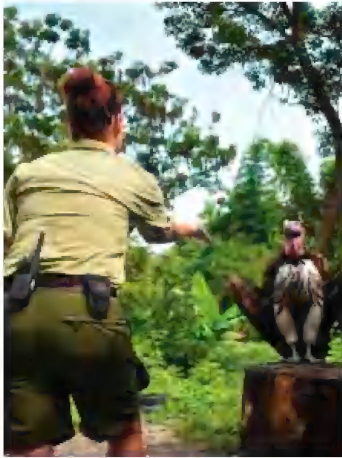
The "variable schedules" you are using may not actually be variable, or even intermittent. Even if you are using true intermittent schedules, you may want to reconsider when and why you use them.

## Schedules of Reinforcement

From a scientific perspective, schedules of reinforcement fall into two broad categories: continuous and intermittent. In a continuous schedule, every correct response is reinforced. A correct response is a response that meets the trainer's criteria. We assume here that the trainer is only reinforcing correct responses. The criteria might change over time as a response is shaped, but any response that meets the current criteria is a correct response. In an intermittent schedule, some correct responses are reinforced, and others are not. Intermittent schedules can take several forms, and are typically identified using a two-word descriptor. The first word describes how the requirements for reinforcement are scheduled (e.g., fixed, variable, random), and the second word describes the type of requirement (e.g., time, ratio, interval, duration). For more information about

*Gorilla with infant*





Vulture stationing.

some of the most common schedules, including examples, please see the AZA/AAZK Animal Training Terms and Definitions at <https://tinyurl.com/trainingterms2016>.

In this discussion we will focus on ratio schedules because they have been commonly used and commonly misunderstood in the animal training community. In a ratio schedule, access to the reinforcer depends on the number of correct responses. In a ratio schedule, a reinforcer might be delivered after one correct response, or three or five. When the number of correct responses required is held constant, the schedule is described as a fixed ratio (FR). An FR1 schedule is a continuous schedule of reinforcement. A fixed ratio schedule requiring more than one correct response per reinforcer (FR2, FR3, etc.) is an intermittent schedule. A schedule in which a variable number of correct responses is required is a variable ratio (VR) schedule. For example, in a VR5 schedule, a reinforcer might be delivered after as few as one correct response or as many as ten. The response requirement will vary between those two extremes in a carefully planned arrangement with an average response requirement of five. Over the years, trainers have sometimes



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used the term “variable schedule” to describe techniques that do not fall into the definitions above. One example is the use of a variety of different reinforcers during a training session to keep the animal’s motivation high. In many cases, trainers have also been able to reduce their use of food by offering different conditioned or secondary reinforcers after a correct behavior (Ramirez, 2014). In these cases trainers are using continuous reinforcement with a variety of reinforcers. Ramirez suggests that trainers use the term “reinforcer variety” to describe this practice, which is different from a variable ratio schedule. Another example of the misuse of the term “variable schedule” is when a trainer uses a bridging stimulus (clicker, whistle, etc.) after every correct response, but only “pays” (provides a backup reinforcer) after some correct responses. This is not a variable-ratio schedule and is not advisable. We will discuss this practice in more detail in a future column on conditioned reinforcement. When using a bridge, a variable-ratio schedule would involve delivering both the bridge and the backup reinforcer on some trials, and withholding both the bridge and the reinforcer on other trials in a carefully planned arrangement.

### Free Operant vs. Discrete Trial Training

When trying to understand the general effects of variable ratio schedules, it may be useful to consider the type of procedure used to train a particular behavior. When discussing the typical effects of various schedules of reinforcement, we often talk about the rate of behavior. For instance, a variable ratio schedule typically produces steady, high rates of behavior and a fixed interval schedule typically produces a scalloped pattern where the rate of behavior increases just before a reinforcer becomes available and then declines sharply just after a reinforcer is delivered. Sometimes trainers attempt to use variable ratio schedules because the prospect of producing steady, high rates of behavior sounds attractive. But

this effect is only possible in a certain type of training procedure.

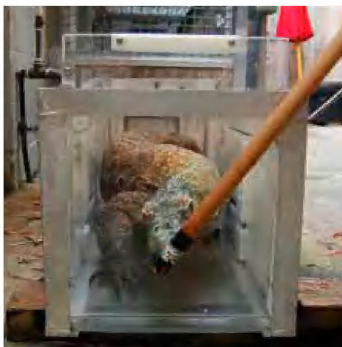
In some training procedures, there is a period of time between the delivery of a reinforcer and the cue for the next behavior, during which the trainer does not offer reinforcement. If the animal offers a trained behavior during this period, the trainer does not reinforce it. This period is called an intertrial interval. In a free operant training procedure, there is no intertrial interval. After a reinforcer is delivered, more reinforcers are available if responses keep occurring. For example, think about a crow using a stick to extract grubs from a crevice in a log. The crow may or may not successfully obtain a grub every time the twig is inserted, so the schedule of reinforcement may be continuous or intermittent. But the crow does not have to wait before trying again; the stick can be inserted repeatedly as fast as the crow can move. This means that there is no intertrial interval and this is a free operant procedure. If grubs are available on a variable ratio schedule, the crow is likely to insert sticks at a steady, high rate. Free operant arrangements are very common in natural environments, and much of what we know about schedule effects comes from experiments using free operant procedures.

In a discrete trial training procedure, there is always a cue/discriminative stimulus. This is followed by a single response and an outcome (for example, a reinforcer). Then the next trial starts after an intertrial interval. For example, consider a husbandry training session in which the trainer asks a Komodo dragon to touch a target. The trainer gives a cue, the dragon performs the correct behavior, and the trainer delivers a reinforcer. Until the trainer gives the next cue, no further reinforcers are available for touching the target. This period between the delivery of a reinforcer and the delivery of the next cue is the intertrial interval. Even if the trainer uses an intermittent schedule of reinforcement (reinforces some correct responses and not others), the dragon’s

rate of responding is limited by the rate at which the trainer delivers cues. In this type of procedure, we can measure the percent of trials on which the animal makes a correct response. Rate of behavior will not be a useful measure in this procedure, because the trainer is controlling the rate of behavior via the intertrial interval. This is the type of procedure most often used in husbandry and medical training in zoological settings.

As we have worked with our teams on integrating science into our behavioral husbandry program, one thing that has emerged as critically important is the need to understand the reasons behind best practice recommendations. This gets us away from statements that include “always” or “never”, and moves us toward customizing our techniques to individual needs and goals. Many animal trainers have heard that it is best to always use a continuous schedule of reinforcement when teaching a new behavior, and then to always transition to a variable ratio schedule to maintain the behavior. Often the reasons behind this recommendation get lost. When behavior scientists recommend transitioning from continuous to intermittent reinforcement, it is typically because the ultimate goal is for the behavior to occur without depending on the trainer asking for it and reinforcing it every time (Hanley & Tiger, 2011). For the majority of husbandry and medical training, that is not the case. When we train a tiger to open her mouth, a zebra to raise his hoof, or a gorilla to station for a blood draw, the ultimate goal is the successful performance of the behavior on cue to facilitate tooth brushing, a hoof trim, or sample collection. We do not expect or need the animals to demonstrate these behaviors without the trainer present to deliver reinforcers, so there is no clear advantage to using an intermittent schedule of reinforcement. To effectively maintain behavior, a variable ratio schedule needs to be carefully planned and implemented (Cooper, Heron, and Heward, 2007 p. 309). In practice, trainers intending to





Komodo Dragon target training.

use a variable ratio schedule typically implement a haphazard schedule instead. One serious risk of this practice is accidentally requiring more responses than the animal is prepared to offer for a reinforcer. This can result in unpredictable delays in responding, refusal to participate, and/or aggression (Cooper et al., 2007 p. 314). When there is no clear benefit to an intermittent schedule, we recommend keeping the training plan straightforward and sticking with a continuous reinforcement schedule. With this type of schedule, communication with the animal is clear and no special planning is needed.

There are some husbandry training situations in which intermittent schedules are useful. The benefit offered by a variable ratio schedule is that the animal is more likely to persist in performing the behavior when trainer-delivered reinforcers are not available. In some situations, this is an important benefit. For example, some female primates need assistance learning to tolerate infant nursing. While initially a trainer might work with the animal to train this behavior using a hand-delivered food reinforcer, the ultimate goal is for the animal to allow an infant to nurse without the trainer's involvement. To facilitate learning in this case, the trainer might gradually transition from a continuous schedule to an intermittent schedule of reinforcement. Each step in this transition would be carefully planned to ensure that the desired behavior is

maintained. Ideally, as reinforcement delivered by the trainer becomes less frequent, natural reinforcers will become more frequent. Successful nursing interactions should produce an increase in oxytocin concentration for the mother. The intermittent reinforcement provided by the trainer will help the trained behavior to persist long enough to produce natural reinforcers that will keep the behavior going even without the trainer. Although there are certainly other situations in which careful use of intermittent schedules of reinforcement might be beneficial, in a typical discrete-trial husbandry or medical training procedure a continuous schedule of reinforcement is the most practical and effective strategy for clearly communicating with an animal and producing consistently accurate behavior. Sometimes trainers worry that using a continuous schedule of reinforcement will create an expectation that reinforcement will be delivered after every correct response, and if the trainer makes one mistake or is unable to deliver a reinforcer one time the animal will stop responding. It may be helpful to know that maintaining a behavior on a continuous schedule of reinforcement over a long period of time is another way to build persistence (Vollmer & Athens, 2011).

## Conclusions

When discussing science-based behavioral husbandry, we do not advocate a hard-and-fast rule-based approach. There are very few absolute rules about what a trainer must *always* or *never* do to be successful. Instead we advocate continuing to learn about scientifically supported approaches and then tailoring behavior management plans to each individual animal's needs and challenges. For this particular topic, we conclude with a few brief suggestions.


**Think about your ultimate goals for the behavior you are training.** What is the purpose of the behavior? Under what circumstances will it need to occur? Will the animal need to perform this behavior when the trainer is not present?

**Think about the type of procedure supporting the behavior.** Think about the training procedure and the situation in which the animal will ultimately need to perform the behavior. For each of these, are reinforcers available in a free operant or discrete trial arrangement?

**Try continuous reinforcement - it might work!** If you are using a continuous schedule of reinforcement and your animal is disengaged, it may be worthwhile to re-evaluate some other aspects of your training before considering an alternative schedule. These could include but are not limited to the quality of your chosen reinforcer(s); timing and consistency of your cues, bridge, and reinforcer delivery; strength of your bridge.

**Watch your animal's response.** Be sure to define what success looks like in your training and watch your animal closely to monitor progress.

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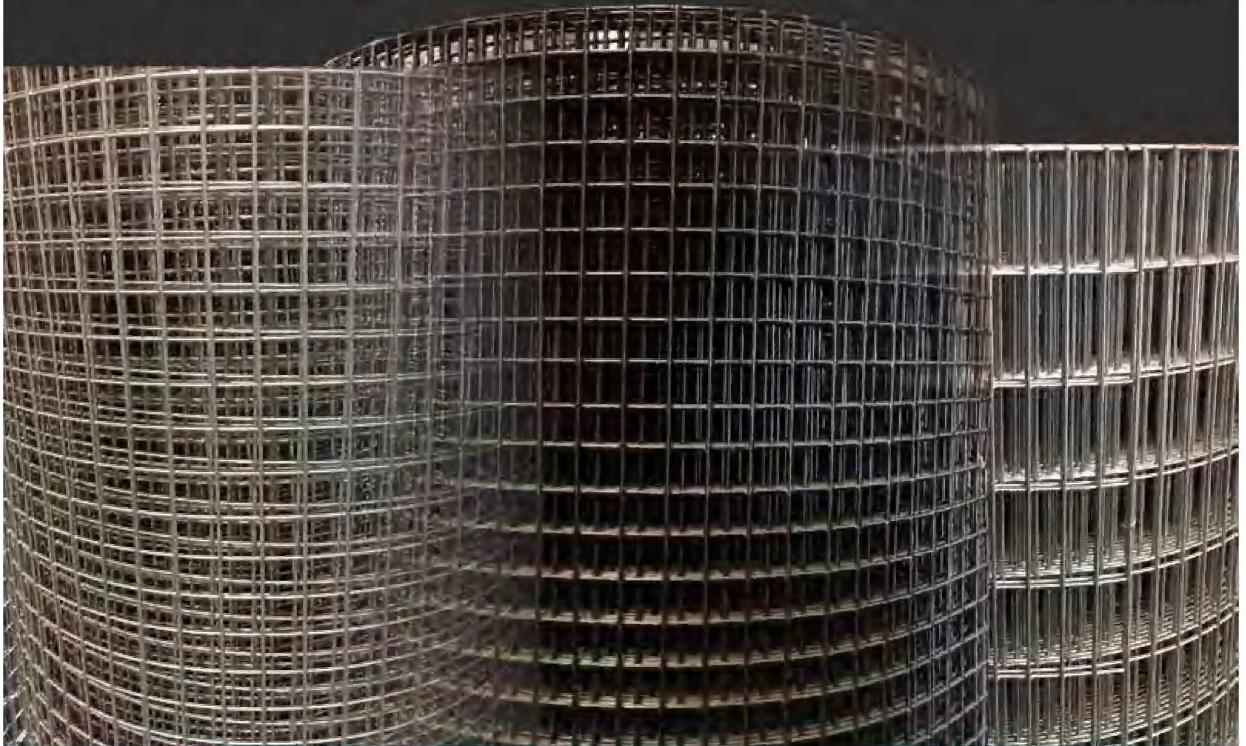
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